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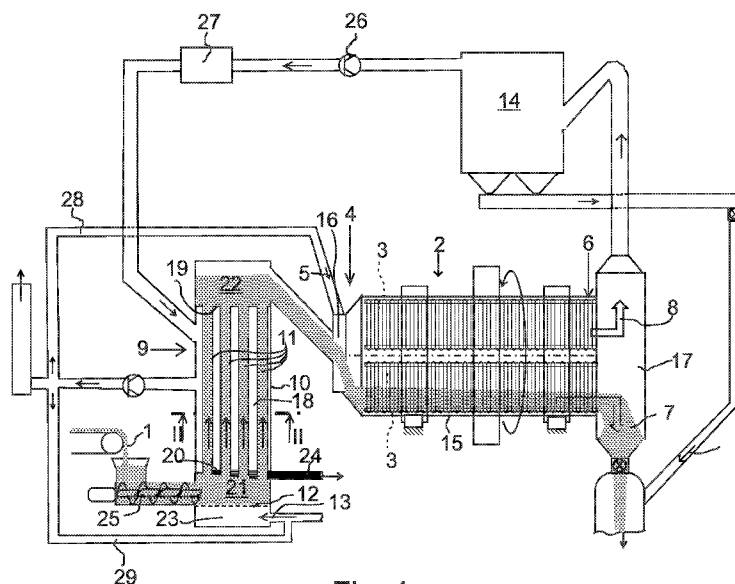


Fig. 1

(57) Abstract: A method and an apparatus for drying moist material (1) by an apparatus including a drier (2). Prior to feeding the material (1) to the drier (2), the material is preheated to an elevated temperature in a preheater (9) based on recuperative indirect heat transfer, wherein the latent energy released in a phase transition from the vapor phase to the aqueous phase of the water vapor included in the exhaust gas (8) is transferred to the preheating of the moist material.

METHOD AND APPARATUS FOR DRYING MOIST MATERIAL

FIELD OF THE INVENTION

The invention relates to a method as defined in the preamble of claim 1. Further, the invention relates to an apparatus as defined in the preamble of claim 13.

BACKGROUND OF THE INVENTION

Known from the prior art, for example from publications FI 105130 B, US, 415,527 and EP 2 249 113 A1, are steam driers for drying moist material.

Such driers are typically continuously operated steam driers, in the interior of which there is a steam pipework co-rotating with the drier and through which a flow of the material to be dried is passed. A steam drier comprises a substantially horizontal elongated drum to be rotated about its longitudinal axis. The steam pipework is provided in the interior of the drum and combined to the drum to co-rotate with the drum. The steam pipework is fed with water vapor, whereupon the material to be dried is provided in heat transfer communication with the steam pipework as the drum rotates for evaporating the water included in the material, and the material is dried in the drum as it advances from a first end to a second end. The steam drier is fed with moist material from the first end of the steam drier, and carrier gas is simultaneously conveyed to the interior of the drum. The dried material and hot and moist exhaust gas are discharged from the second end of the steam drier. The exhaust gas contains carrier gas and water vapor evaporated from the material. Solid particles are separated from the moist exhaust gas by a dust separator, and the exhaust gas is then released into the atmosphere.

For example in the case where the material to be dried is an ore concentrate stored in the open air, it may typically include approximately 5 to 15% of water which is heated to above 100°C in the steam drier, and the concentrate is heated to a temperature of 100°C to 140°C. The exhaust gas discharged from the steam drier has a water vapor content of approximately 30 to 60% of the total amount of the exhaust gas, the rest being carrier gas and other gaseous compounds evaporated from the concentrate.

Known from the prior art are also driers based on direct heat transfer occurring from the combustion gases of a fuel to be burnt in a drying chamber to the material to be dried, in which case the combustion gases also partially function as carrier gas. The total amount of exhaust gas is greater and its water vapor content is lower than in a steam drier.

The problem is that the energy content of the exhaust gas from the drier has not been utilized in any way in the prior art, and thus a significant portion of the total amount of energy to be used for drying has been lost with the exhaust gas.

A further problem is that the material to be fed to the drier at the ambient temperature immediately condenses more moisture onto its surface as it enters the drier at the inlet end. As this happens in the case of a rotating steam drier, the material becomes lumpy and sticks to the surface of the steam pipework, not moving in the interior of the drum by rolling as it should; instead, it sticks to the pipework as the drum rotates, rising up and crashing all down in lumps,

hindering the functioning of the device and subjecting the device to mechanical stresses.

5 **OBJECTIVE OF THE INVENTION**

The objective of the invention is to eliminate the drawbacks referred to above.

10 In particular, it is an objective of the invention to disclose a method and an apparatus by which the energy content of the exhaust gas from the drier can be utilized and the energy economy of the drying can be considerably improved to provide considerable savings.

15 Further, it is an objective of the invention to disclose a method and an apparatus improving the behavior of the material in the interior of the drier.

20 **SUMMARY OF THE INVENTION**

The method according to the invention is characterized by what has been presented in claim 1. The apparatus according to the invention is characterized by what has been presented in claim 13.

25 According to the invention, prior to feeding the material to the drier it is preheated in the method to an elevated temperature in a preheater based on recuperative indirect heat transfer, wherein the material is
30 preheated by the latent energy released in a phase transition from the vapor phase to the aqueous phase of the water vapor included by the exhaust gas.

According to the invention, the apparatus includes a
35 preheater based on recuperative indirect heat transfer for preheating the moist material to be fed to the

drier to an elevated temperature by the latent energy released in a phase transition from the vapor phase to the aqueous phase of the water vapor included in the exhaust gas.

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The advantage of the invention is that the latent energy of the water vapor from the exhaust gas, which has not been utilized before, can be effectively utilized to preheat the material to be dried, by virtue of which the energy requirement of the drying is reduced for up to 20% and considerable cost savings can thus be reached. Further, it is an advantage of the invention that the material to be dried which is preheated from the ambient temperature to an elevated temperature does not bind additional moisture to its surface as it enters the drier, so its mechanical movement properties in the interior of the drying drum are improved. The warm material does not have any lumping tendency. The method and apparatus is suitable for drying any material, whether the material be inorganic or organic. As examples of some of the preferred applications, the drying of minerals, oil sand, slurry, wood-based material and mixed municipal waste can be mentioned.

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In one embodiment of the method, a preheater is provided, having a substantially vertical casing, in the interior of which there are a number of pipes which are substantially vertical or inclined relative to the vertical direction and spaced apart from each other so that a space is delimited in the interior of the casing of the chamber around the pipes for the purpose of receiving the exhaust gas. The material to be preheated is conveyed to the pipes. Exhaust gas is conveyed to the space surrounding the pipes so that the water vapor of the exhaust gas is condensed to the external surface

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of the pipes, imparting its phase transition energy to the material passing in the interior of the pipes.

5 In one embodiment of the method, the material to be preheated is introduced onto a fluidized bed at the bottom part of the preheater, from which the material is fluidized from the bottom to the top of the pipes by means of a fluidizing gas. The preheated material is discharged from the top part of the preheater and conveyed to the
10 drier.

In one embodiment of the method, the material to be preheated is introduced to the top part of the preheater, from which the material moves down in the pipes mainly
15 by means of gravity, and the preheated material is discharged from the bottom part of the preheater and conveyed to the drier.

20 In one embodiment of the method, the temperature of the exhaust gas is kept above the dew point prior to the preheater.

In one embodiment of the method, the moist material is heated to a temperature of approximately 40 to 90°C in
25 the preheater.

In one embodiment of the method, the moist material contains approximately 5 to 30% of water.

30 In one embodiment of the method, the exhaust gas has a water vapor content greater than 10%.

In one embodiment of the method, the warm exhaust gas from which water has been condensed out is discharged
35 from the preheater. Part of this exhaust gas is con-

veyed to the steam drier as a carrier gas and/or to the preheater as a fluidizing gas.

5 In one embodiment of the method, part of the exhaust gas from which water has been condensed out and which is discharged from the preheater is directed to the bottom part of the preheater.

10 In one embodiment of the method, dust is separated from the exhaust gas by a dust separator prior to directing it to the preheater.

15 In one embodiment of the apparatus, the preheater includes a casing which is substantially vertical or slightly inclined relative to the vertical direction, and a number of pipes provided in the interior of the casing in parallel to and spaced apart from each other so that a heat transfer space to which the exhaust gas can be conveyed is delimited in the interior of the chamber around the pipes, the moist material to be pre-
20 heated being adapted to move in the interior of said pipes for preheating the material by the latent energy released in a phase transition of the exhaust gas provided in the exterior of the pipes.

25 In one embodiment of the apparatus, the preheater includes a top wall which delimits the heat transfer space in the upward direction, and to which the top ends of the pipes are attached in a gas tight manner. Further,
30 the preheater includes a bottom wall which delimits the heat transfer space in the downward direction, and to which the bottom ends of the pipes are attached in a gas and water tight manner.

35 In one embodiment of the apparatus, the preheater includes an inlet chamber at the first end of the preheat-

er for receiving the material to be preheated and transferring it to the pipes. Further, the preheater includes an outlet chamber at the second end of the preheater for receiving the preheated material from the pipes and transferring it further to the drier.

In one embodiment of the apparatus, the inlet chamber is disposed below the bottom wall and the outlet chamber is disposed above the top wall.

10

In one embodiment of the apparatus, the preheater includes a fluidized bed spaced apart from the bottom wall below the bottom wall, forming the base of the inlet chamber to which the material to be preheated can be introduced. Further, the preheater includes a gas distribution chamber disposed below the fluidized bed for distributing a fluidizing gas to the fluidized bed for fluidizing the material from the inlet chamber at the bottom to the outlet chamber at the top.

20

In one embodiment of the apparatus, the inlet chamber is disposed above the top wall and the outlet chamber is disposed below the bottom wall.

25 In one embodiment of the apparatus, the bottom wall is horizontal or disposed in an inclined position relative to the horizontal direction. The preheater includes an exhaust duct opening to the heat transfer space in the immediate vicinity of the bottom wall for discharging any condensed water accumulated onto the bottom wall.

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In one embodiment of the apparatus, the apparatus includes a feeding device for feeding the material to the inlet chamber.

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In one embodiment of the apparatus, the apparatus includes a dust separator, such as a bag filter, for removing dust from the exhaust gas to be conveyed to the preheater.

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In one embodiment of the apparatus, the apparatus includes a blower for raising the pressure of the exhaust gas to be conveyed to the preheater.

- 10 In one embodiment of the apparatus, the apparatus includes a heating device for raising the temperature of the exhaust gas to be conveyed to the preheater.

- 15 In one embodiment of the apparatus, the apparatus includes a first gas duct for conveying part of the exhaust gas to be discharged from the preheater to the drier as a carrier gas.

- 20 In one embodiment of the apparatus, the apparatus includes a second gas duct for conveying part of the exhaust gas to be discharged from the preheater to the gas distribution chamber as a fluidizing gas.

- 25 In one embodiment of the apparatus, the apparatus includes a third gas duct for conveying part of the exhaust gas to be discharged from the preheater to the outlet chamber.

- 30 In one embodiment of the apparatus, the drier is a steam drier with an elongated rotatable drum as the drying chamber. The steam drier includes a steam pipework provided in the interior of the drum and combined with the drum to co-rotate with the drum. The steam pipework can be fed with water vapor, whereupon the material to be dried is provided in heat transfer communi-
- 35

cation with the steam pipework as the drum rotates for evaporating the water included in the material.

LIST OF FIGURES

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In the following section, the invention will be described in detail using exemplifying embodiments with reference to the accompanying drawing in which

10 Fig. 1 schematically illustrates a first embodiment of the apparatus according to the invention by which one embodiment of the method according to the invention can be carried out,

15 Fig. 2 illustrates section II-II of Fig. 1, and

Fig. 3 schematically illustrates a second embodiment of the apparatus according to the invention by which a second embodiment of the method according to the invention can be carried out.

20

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 and 3 schematically illustrate an apparatus for drying moist material. The material to be dried may include minerals, oil sand, wood-based material, such as dust and wood bark slurry, or mixed municipal waste. The apparatus can be added to a larger process line to constitute a part of it, whether the process be a smelting process, a biogasification process or any other process.

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The apparatus firstly includes, mainly in the flow direction of the moist material 1, a preheater 9 from which the preheated moist material is passed to a dry-

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ing chamber 15 of a steam drier 2, wherein the moist material is dried.

5 The drying chamber of the steam drier 2 is an elongated rotatable drum 15. The interior of the drum 15 is provided with a steam pipework 3 combined with the drum to co-rotate with the drum. The steam pipework 3 can be fed with water vapor, so that the water is removed from the moist material by evaporation as the
10 drum 15 rotates and the material 1 to be dried is provided in heat transfer communication with the steam pipework 3.

A first end 4 of the drum is provided with an inlet
15 connection 16 via which the interior of the drum 15 can be fed with the moist material 1 and a carrier gas 5. A second end of the drum 15 is provided with an exhaust chamber 17 receiving the dried material 7 from the drum as well as the exhaust gas 8 including carrier
20 gas 5 and hot water vapor evaporated from the moist material. In one preferred example case, the moist material to be fed to the steam drier 2 has a water content of 5 to 20%, in which case the exhaust gas 8 will have a water vapor content of 10 to 60%, and its tem-
25 perature is kept above the dew point.

From the exhaust chamber 17, the dried material 7 is passed for further treatment by a conveyor. The exhaust gas 8 is conveyed to a filter 14, wherein dust
30 is separated from the exhaust gas. The dust separated at the filter 14 is conveyed with the dried material 7 to a next process step.

From the filter 14, the purified exhaust gas 8 is con-
35 veyed to the preheater 9. At this stage, the exhaust

gas can be pressurized by a blower 26 and/or heated by a heating device 27 as needed.

5 The purified moist and hot exhaust gas 8 is utilized to preheat the moist material 1 to be fed to the steam drier 2 at the preheater 9 based on recuperative indirect heat transfer. At the preheater 9, the moist material 1 is preheated to an elevated temperature by the latent energy released in a phase transition from
10 the vapor phase to the aqueous phase of the water vapor included in the exhaust gas 8.

The preheater 9 includes a casing 10 which is substantially vertical or slightly inclined relative to the
15 vertical direction. The casing 10 may be cylindrical (as in Fig. 2) or shaped as a prism. With reference likewise to Fig. 2, the preheater 9 further includes a number of elongated pipes 11 provided in the interior of the casing in parallel to and spaced apart from
20 each other so that a heat transfer space 18 to which the exhaust gas 8 can be conveyed is delimited in the interior of the casing 10 around the pipes 11, the moist material 1 to be preheated being adapted to move in the interior of the pipes 11 for heating the material by the latent energy released in a phase transition of the exhaust gas 8 present in the exterior of
25 the pipes.

The preheater includes a top wall 19 which delimits
30 the heat transfer space 18 in the upward direction and to which the top ends of the pipes 11 are attached in a gas tight manner, and a bottom wall 20 which delimits the heat transfer space in the downward direction and to which the bottom ends of the pipes are attached
35 in a gas and water tight manner.

In the example of Fig. 1, the preheater 9 includes an inlet chamber 21 at the bottom end of the preheater for receiving the material 1 to be preheated and transferring it to the pipes 11, and an outlet chamber 22 at the top end of the preheater for receiving the preheated material from the pipes and transferring it further to the steam drier 2. The inlet chamber 21 is thus disposed below the bottom wall 20 and the outlet chamber 22 is disposed above the top wall 19. The preheater 9 includes a fluidized bed 12 spaced apart from the bottom wall 20 below the bottom wall, constituting the base of the inlet chamber 21 onto which the material 1 to be preheated can be introduced by a feeding device 25 illustrated herein as a screw conveyor. Below the fluidized bed 12 there is a gas distribution chamber 23 for distributing a fluidizing gas 13 onto the fluidized bed for fluidizing the material from the inlet chamber 21 at the bottom to the outlet chamber 22 at the top.

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The embodiment of Fig. 3 differs from the example of Fig. 1 in that the flow direction of the material 1 in the preheater 9 is oriented from the top to the bottom, in which case the flow of the material 1 in the pipes 11 is mainly gravitational. In this case, the inlet chamber 21 is disposed above the top wall 19 and the outlet chamber 22 is disposed below the bottom wall 20. The residence time of the material in the preheater can be adjusted based on a level detector 30 detecting the level of the material 1 in the inlet chamber 21. A signal obtained from the level detector can be used to control a first rotary feeder 31 adjusting the amount of the material flow discharged from the outlet chamber 22 to the steam drier 2. In the embodiment of Fig. 3, the feeding device 25 feeding the material 1 to the inlet chamber 21 is a second

rotary feeder 32. If desired, the inlet chamber 21 and/or the outlet chamber 22 can also be pressurized for enhancing the flow of the material 1 and for opening any possible blockages.

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With further reference to Fig. 1 and 3, the bottom wall 20 may be disposed in an inclined position relative to the horizontal direction. The preheater includes an exhaust duct 24 opening into the heat transfer space 18 in the immediate vicinity of the bottom wall 20 for discharging the condensed water accumulated onto the bottom wall.

The apparatus of Fig. 1 includes a first gas duct 28 for conveying the exhaust gas to be discharged from the preheater 9 into the steam drier 2 as a carrier gas 5, and additionally a second gas duct 29 for conveying the exhaust gas to be discharged from the preheater 9 into the gas distribution chamber 23 as a fluidizing gas 13.

The apparatus of Fig. 3 has a first gas duct 28 for conveying part of the exhaust gas to be discharged from the preheater 9 into the steam drier 2 as a carrier gas 5. In addition, a third gas duct 33 is provided for conveying part of the exhaust gas to be discharged from the preheater 9 to the outlet chamber 22 of the preheater to aid the flow of the material.

The apparatus of Fig. 1 and 3 can be used to carry out a method, wherein a steam drier 2 is rotated and continuously fed with moist material 1 to the steam drier 2 from a first end 4. Carrier gas 5 is conveyed to the steam drier 2. Water vapor is conveyed via a steam pipework 3, whereupon the heat is transferred from the water vapor included in the steam pipework through in-

direct heat transfer by being conducted through the wall of the steam pipework to the material so that the water present in the material is evaporated to water vapor. Dried material 7 is discharged from a second
5 end 6 of the steam drier, as well as exhaust gas 8 including carrier gas 5 and water vapor. The temperature of the exhaust gas 8 is kept above the dew point. The exhaust gas 8 and the dried material 7 are separated from each other in an exhaust chamber 17.

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Prior to feeding the material 1 to the steam drier 2, the material is preheated to an elevated temperature in a preheater 9 based on recuperative indirect heat transfer, wherein the latent energy of a phase transition from the vapor phase to the aqueous phase of the
15 water vapor included in the exhaust gas 8 is transferred to the preheating of the moist material 1. This takes place in such a way as to introduce the material 1 to be preheated to a fluidized bed 12 at the bottom part of the preheater 9, from which the material is
20 fluidized from the bottom to the top in pipes 11 by means of a fluidizing gas 13. Exhaust gas 8 is conveyed to a heat transfer space 18 surrounding the pipes 11 so that the water vapor of the exhaust gas 8
25 is condensed to the outer surface of the pipes 11, imparting its phase transition energy to the material 1 which passes in the interior of the pipes and which is heated to a temperature of approximately 40 to 90°C. The preheated material 1 is discharged from the top
30 part of the preheater and conveyed to the steam drier 2.

In the embodiment of Fig. 3, the material 1 to be preheated is introduced to the top part of the preheater
35 9, from which the material moves down in the pipes 11 mainly by means of gravity, and the preheated material

1 is discharged from the bottom part of the preheater and conveyed to the steam drier 2.

At least part of the warm exhaust gas 8 from which water has been condensed out and which is discharged from the preheater 9 can be conveyed to the steam drier 2 as a carrier gas 5 by a first gas duct 28. Additionally in the embodiment of Fig. 1, part of the exhaust gas discharged from the preheater can be conveyed to the preheater 9 as a fluidizing gas 13 by a second gas duct 29. Further in the embodiment of Fig. 3, part of the exhaust gas discharged from the preheater can be conveyed to the exhaust chamber 22 by a third gas duct 33.

15

While the invention has been described in the embodiment examples presented above in conjunction with a steam drier, the invention is not exclusively limited to be used in conjunction with a steam drier; instead, any drier known to a person skilled in the art may be used as the drier within the scope of the invention.

The invention is not limited merely to the exemplifying embodiments referred to above; instead, many variations are possible within the scope of the inventive idea defined by the claims.

CLAIMS

1. A method for drying moist material (1) by an apparatus including a drier (2), in which method

5 - moist material (1) is continuously fed to the drier (2) from a first end (4) of the drier,

 - the material is heated in the drier so that the water present in the material evaporates to water vapor,

10 - dried material (7) and hot and moist exhaust gas (8) including the water vapor evaporated from the material (1) are discharged from a second end (6) of the drier, and

 - the exhaust gas (8) and the dried material (7) are separated from each other, characterized in that

15 prior to feeding the material (1) to the steam drier, (2) the material is preheated to an elevated temperature in a preheater (9) based on recuperative indirect heat transfer, wherein the latent energy released in a phase transition from the vapor phase to the aqueous phase of the water vapor included in the exhaust gas (8) is transferred to the preheating of the moist material.

25

2. The method according to claim 1, characterized in that

 - a preheater (9) is provided, having a substantially vertical casing (10) in the interior of which there is a number of pipes (11) which are substantially vertical or inclined relative to the vertical direction and which are spaced apart from each other so that a space is delimited in the interior of the casing around the pipes for the purpose of receiving the exhaust gas (8),

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- the material (1) to be preheated is conveyed to the pipes (11), and

- exhaust gas (8) is conveyed to the space surrounding the pipes (11) so that the water vapor of the exhaust gas is condensed to the outer surface of the pipes, imparting its phase transition energy to the material (1) passing in the interior of the pipes.

3. The method according to claim 1 or 2, characterized in that the material (1) to be preheated is introduced onto a fluidized bed (12) at the bottom part of the preheater (9), from which the material is fluidized from the bottom toward the top in the pipes (11) by means of a fluidizing gas (13), and the preheated material (1) is discharged from the top part of the preheater and conveyed to the drier (2).

4. The method according to claim 1 or 2, characterized in that the material (1) to be preheated is introduced to the top part of the preheater (9), from which the material moves down in the pipes (11) mainly by means of gravity, and the preheated material (1) is discharged from the bottom part of the preheater and conveyed to the drier (2).

5. The method according to any one of claims 1 to 4, characterized in that the drier (2) is a continuously operated rotating steam drier (2) in the interior of which there is a steam pipework (3) co-rotating with the drier, and in which method the steam drier (2) is rotated and water vapor conveyed via the steam pipework (3), as a consequence of which the heat is transferred from the water vapor included in the steam pipework through indirect heat transfer by being conducted through the wall of the steam pipework to

the material so that the water present in the material evaporates to water vapor.

6. The method according to any one of claims 1 to 5,
5 characterized in that the temperature of the exhaust gas (8) before the preheater (9) is kept above the dew point.

7. The method according to any one of claims 1 to 6,
10 characterized in that the moist material (1) is heated to a temperature of approximately 40 to 90°C in the preheater (9).

8. The method according to any one of claims 1 to 7,
15 characterized in that the moist material (1) includes approximately 5 to 30% of water.

9. The method according to any one of claims 1 to 8,
20 characterized in that the exhaust gas (8) has a water vapor content greater than 10%.

10. The method according to any one of claims 1 to 9,
characterized in that warm exhaust gas (8) from which water has been condensed out is discharged
25 from the preheater (9), and part of the exhaust gas (8) is conveyed to the drier (2) as a carrier gas (5) and/or to the preheater (9) as a fluidizing gas (13).

11. The method according to claim 4, characterized
30 ized in that part of the exhaust gas (8) from which water has been condensed out is conveyed to the bottom part of the preheater (9).

12. The method according to any one of claims 1 to 11,
35 characterized in that the dust is separated

from the exhaust gas (8) by a dust separator (14) prior to conveying it to the preheater (9).

13. An apparatus for drying moist material, which apparatus includes a drier (2) including

- a drying chamber (15),
- an inlet connection (16) at a first end (4) of the drying chamber, via which inlet connection the moist material (1) can be fed to the interior of the drying chamber, and
- an outlet chamber (17) at a second end (6) of the drying chamber for receiving from the drying chamber the dried material (7) and exhaust gas (8) including water vapor evaporated from the moist material, characterized in that the apparatus includes a preheater (9) based on recuperative indirect heat transfer for preheating the moist material (1) to be fed to the drier (2) to an elevated temperature by the latent energy released in a phase transition from the vapor phase to the aqueous phase of the water vapor included in the exhaust gas.

14. The apparatus according to claim 13, characterized in that the preheater (9) includes

- a casing (10) which is substantially vertical or slightly inclined relative to the vertical direction, and
- a number of pipes (11) provided in the interior of the casing in parallel to and at a distance from each other so that a heat transfer space (18) to which the exhaust gas (8) can be conveyed is delimited in the interior of the casing around the pipes, the moist material (1) to be preheated being adapted to move in the interior of the pipes for preheating the material by the latent energy released in a phase

transition of the exhaust gas (8) present in the exterior of the pipes.

15. The apparatus according to claim 14, characterized in that the preheater includes a top wall (19) which delimits the heat transfer space (18) in the upward direction and to which the top ends of the pipes (11) are attached in a gas tight manner, and a bottom wall (20) which delimits the heat transfer space in the downward direction and to which the bottom ends of the pipes are attached in a gas and water tight manner.

16. The apparatus according to claim 14 or 15, characterized in that the preheater (9) includes an inlet chamber (21) at the first end of the preheater for receiving the material (1) to be preheated and transferring it to the pipes (11), and an outlet chamber (22) at the second end of the preheater for receiving the preheated material from the pipes and transferring it further to the drier (2).

17. The apparatus according to claim 16, characterized in that the inlet chamber (21) is disposed below the bottom wall (20) and the outlet chamber (22) is disposed above the top wall (19).

18. The apparatus according to claim 17, characterized in that the preheater (9) includes a fluidized bed (12) spaced apart from the bottom wall (20) below the bottom wall, forming the base of the inlet chamber (21) onto which the material (1) to be preheated can be introduced, and a gas distribution chamber (23) below the fluidized bed (12) for distributing a fluidizing gas (13) onto the fluidized bed for flu-

idizing the material from the inlet chamber (21) at the bottom to the outlet chamber (22) at the top.

19. The apparatus according to claim 16, characterized in that the inlet chamber (21) is disposed above the top wall (19) and the outlet chamber (22) is disposed below the bottom wall (20).

20. The apparatus according to any one of claims 13 to 19, characterized in that the bottom wall (20) is horizontal or is provided in an inclined position relative to the horizontal direction; and that the preheater includes an exhaust duct (24) opening to the heat transfer space (18) in the immediate vicinity of the bottom wall (20) for discharging the condensed water accumulated onto the bottom wall.

21. The apparatus according to any one of claims 13 to 20, characterized in that the apparatus includes a feeding device (25) for feeding the material to the inlet chamber (21).

22. The apparatus according to any one of claims 13 to 21, characterized in that the apparatus includes a dust separator (14), such as a bag filter, for removing the dust from the exhaust gas (8) to be conveyed to the preheater (9).

23. The apparatus according to any one of claims 13 to 22, characterized in that the apparatus includes a blower (26) for raising the pressure of the exhaust gas (8) to be conveyed to the preheater (9).

24. The apparatus according to any one of claims 13 to 23, characterized in that the apparatus includes a heating device (27) for raising the tempera-

ture of the exhaust gas (8) to be conveyed to the preheater (9).

25. The apparatus according to any one of claims 13 to
5 24, characterized in that the apparatus includes a first gas duct (28) for conveying part of the exhaust gas to be discharged from the preheater (9) to the drier (2) as a carrier gas (5).

10 26. The apparatus according to any one of claims 18 to 24, characterized in that the apparatus includes a second gas duct (29) for conveying part of the exhaust gas to be discharged from the preheater (9) to the gas distribution chamber (23) as a fluidizing
15 gas (13).

27. The apparatus according to any one of claims 16 to 24, characterized in that the apparatus includes a third gas duct (33) for conveying part of the
20 exhaust gas to be discharged from the preheater (9) to the outlet chamber (22).

28. The apparatus according to any one of claims 13 to 27, characterized in that the drier is a
25 steam drier (2) having an elongated rotatable drum (15) as the drying chamber (15), the steam drier (2) including a steam pipework (3) which is provided in the interior of the drum and combined with the drum to co-rotate with the drum, and which steam pipework can be
30 fed with water vapor, whereupon the material to be dried is provided in heat transfer communication with the steam pipework as the drum rotates for evaporating the water included in the material.

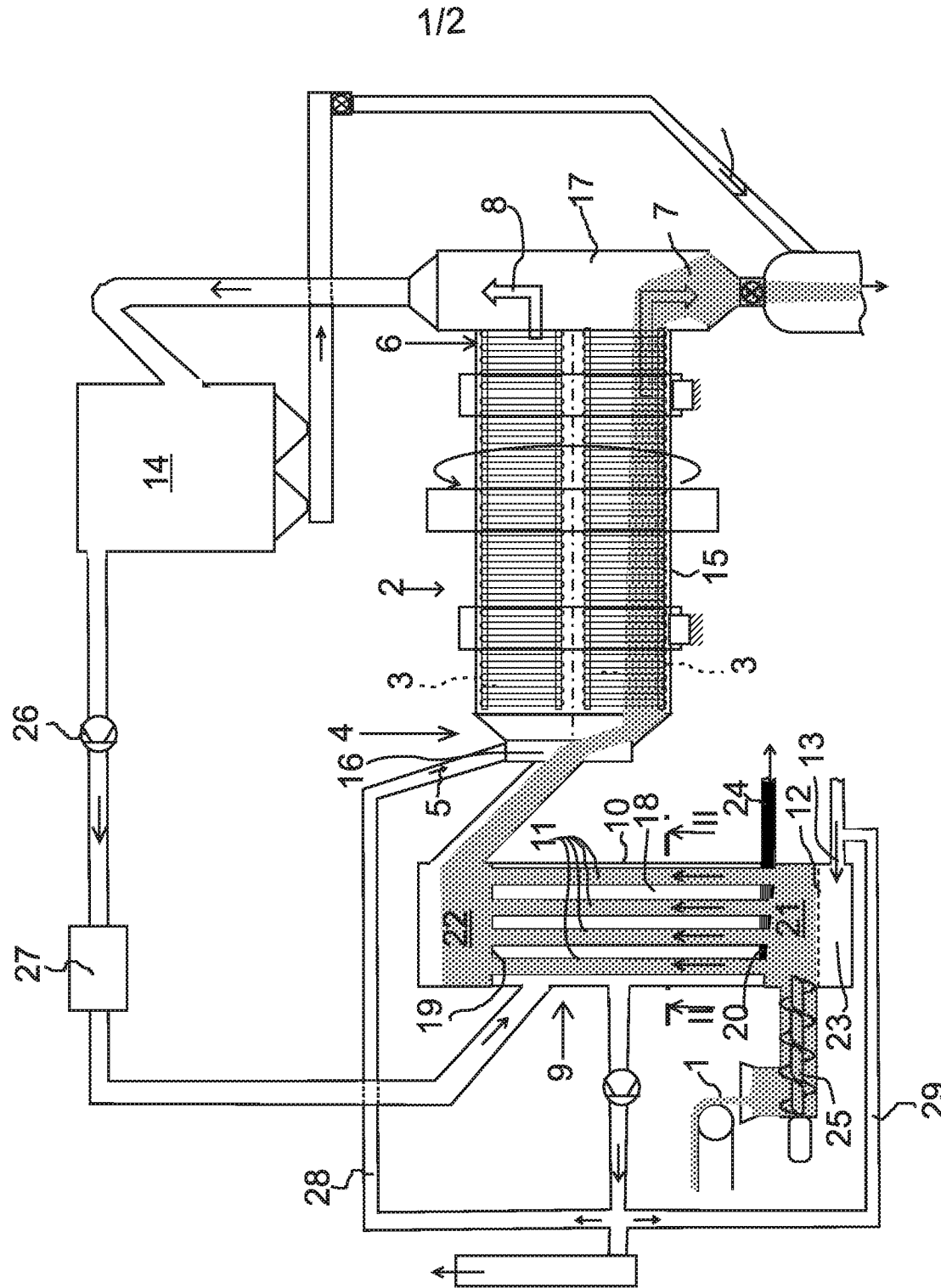


Fig. 1

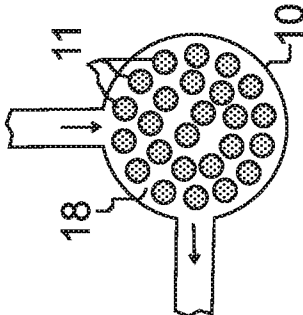


Fig. 2

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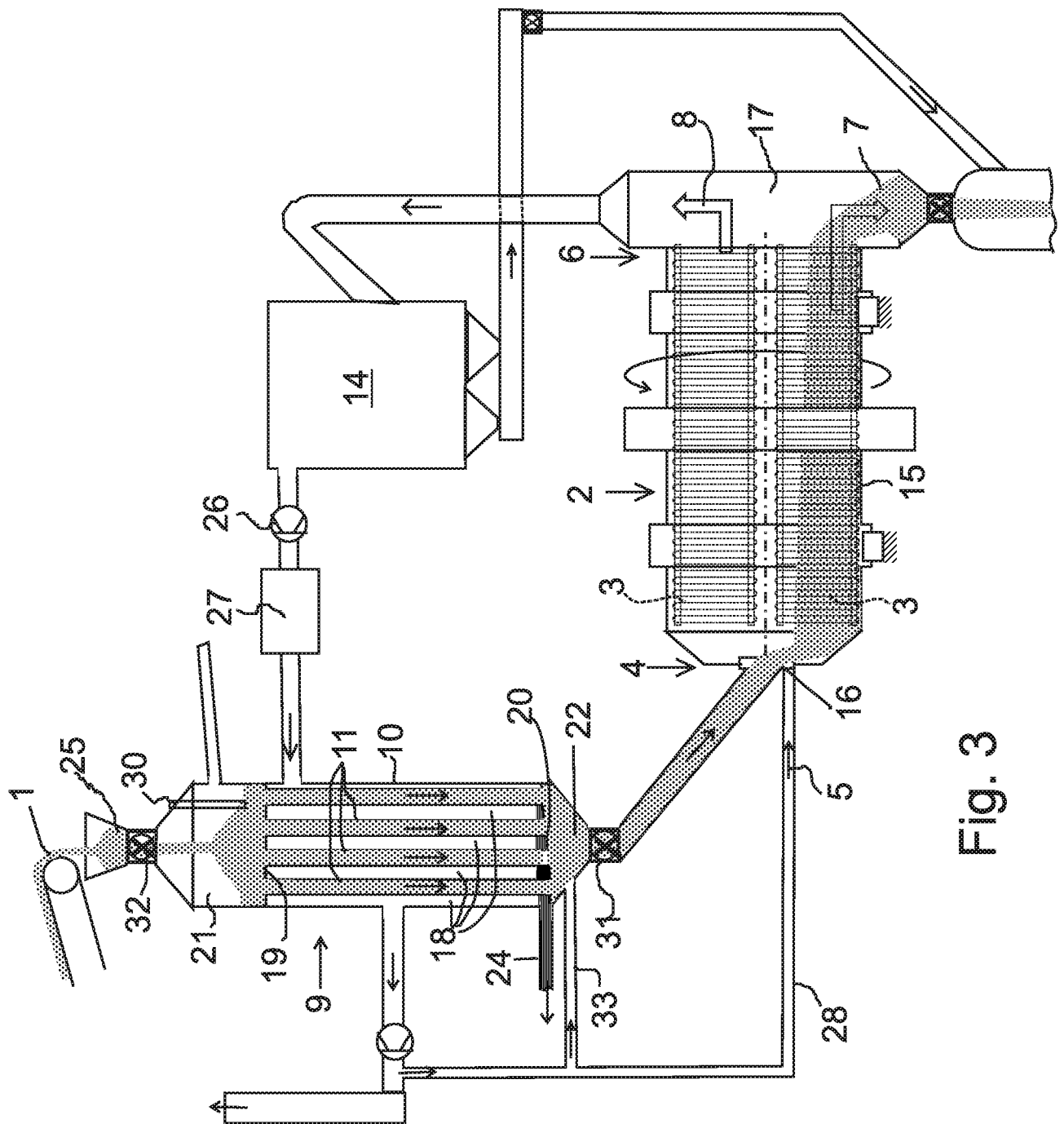


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2011/050171

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F26B, F28B, F28D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
FI, SE, NO, DKElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 20100113947 A (KOREA ENERGY RESEARCH INST et al.) 22 October 2010 (22.10.2010) figures 1-7 & machine translation into English by Thomson Reuters [online] EPOQUENET TXTKRT paragraphs [0001], [0008], [0010], [0015], [0024]	1, 2, 4, 6-9, 11
Y	figures 1-7 & machine translation into English by Thomson Reuters [online] EPOQUENET TXTKRT paragraphs [0001], [0008], [0010], [0015], [0024]	5, 12-17, 19-24, 28
X	US 4058634 A (KUNZ WERNER) 15 November 1977 (15.11.1977) whole document, in particular column 2, lines 7-42, 60-65; figures 1-3	1, 6-9
Y	whole document, in particular column 2, lines 7-42, 60-65; figures 1-3	5, 12
Y	FI 105130 B (KUMERA CORP) 15 June 2000 (15.06.2000) whole document, in particular figure 1 cited in the application	5, 12-17, 19-24, 28

☐ Further documents are listed in the continuation of Box C.
☒ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
02 November 2011 (02.11.2011)

Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2011/050171

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

F26B 17/10 (2006.01)

F26B 17/12 (2006.01)

F26B 23/00 (2006.01)

F28D 1/053 (2006.01)

F28D 13/00 (2006.01)